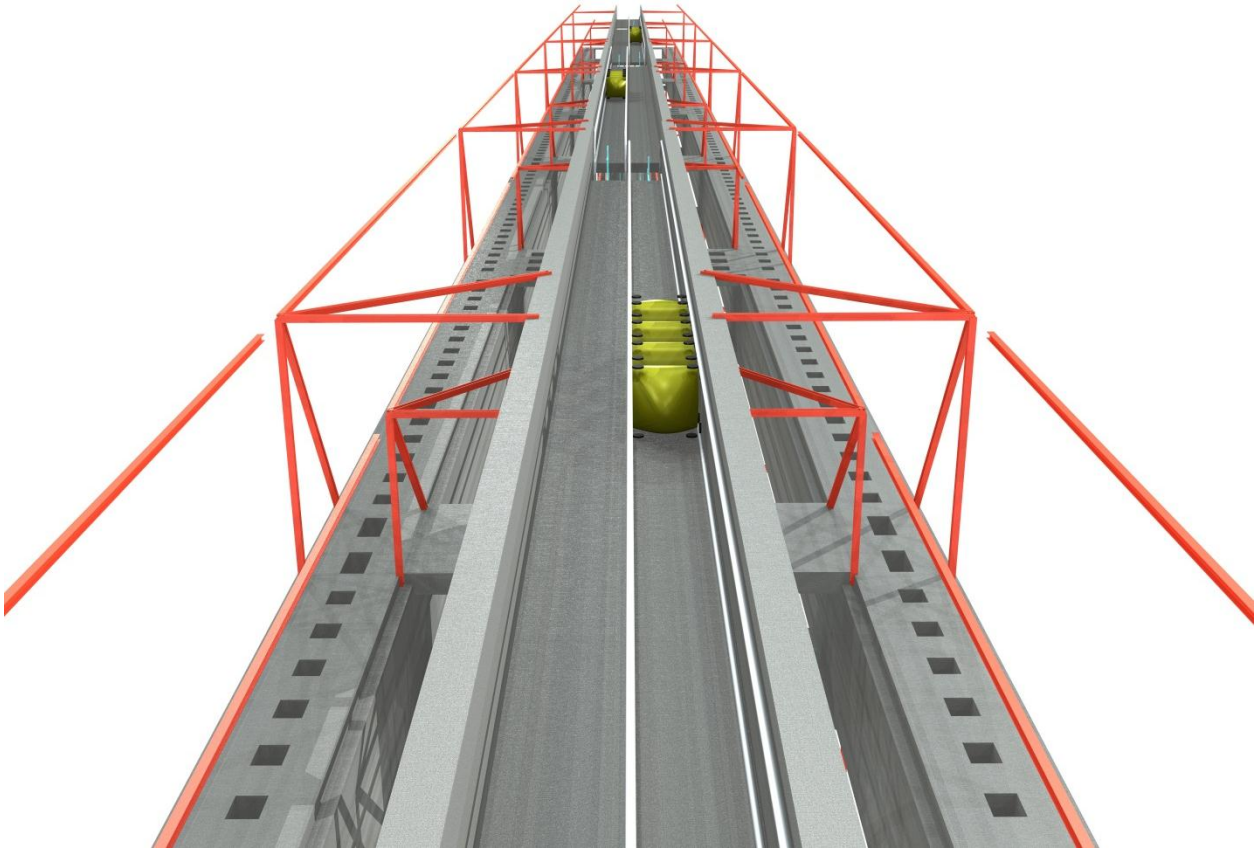
THE ARTICULATED FUNICULATOR and the TUBED MEGA FRAME

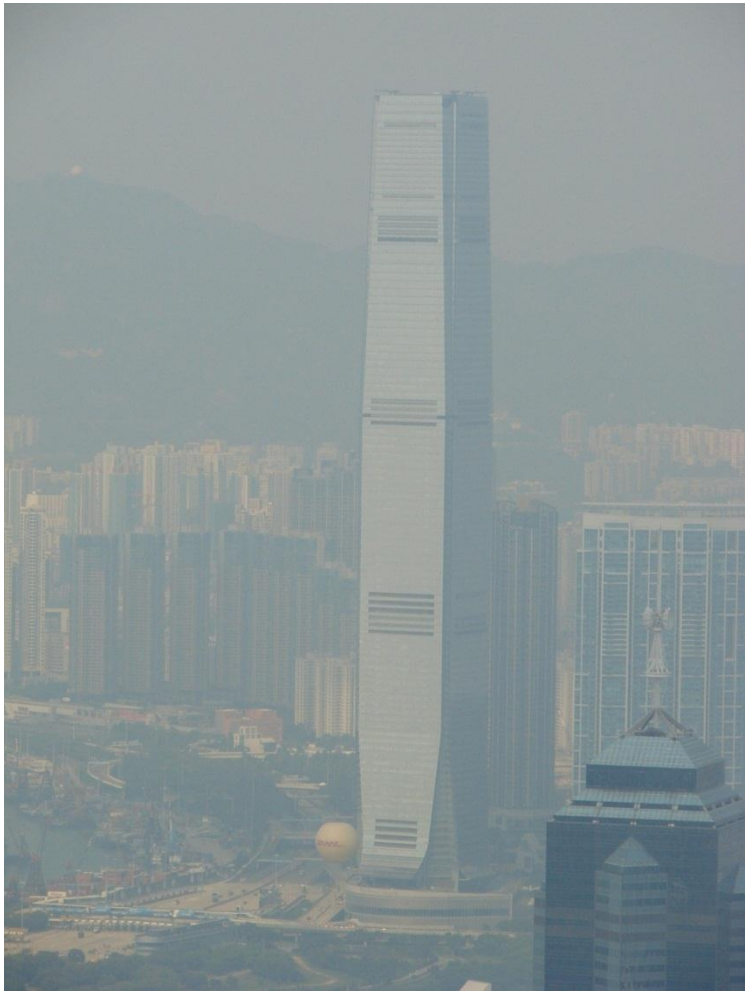


By

Fritz King
Mats Lundström
Sirpa Salavaara
Peter Severin

What happens if a funicular, such as the funicular to Victoria Peak…

Is turned vertical and placed inside a tall thin skyscrapers such as?



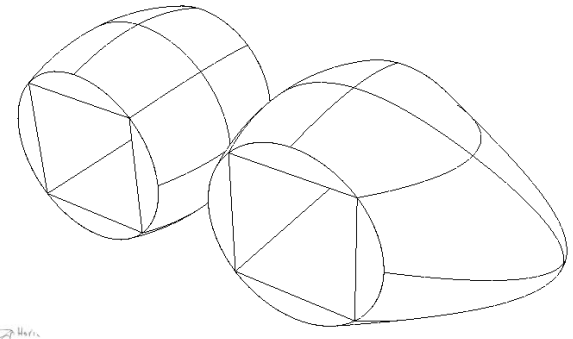
International Commerce Center

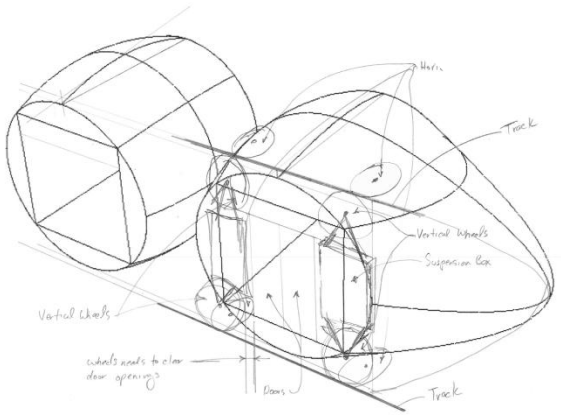
2 International Finance Center

The Articulated Funiculator is Born!

What is the Articulated Funiculator?

- A New and innovative solution to vertical transportation
- Connected system of vertical trains
- Moves people in masse
- Sustainable ”Sky Subway”
- The Way of the Future





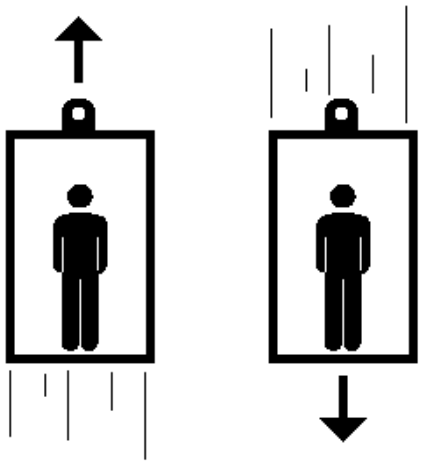
In A Horizontal City

People ride buses and subways as transportation

In A Vertical City

If elevators are the buses

the Articulated Funiculator is the subway



In the words of
noted philosopher and Kyoto Prize winner
Sir Karl Popper 1963:

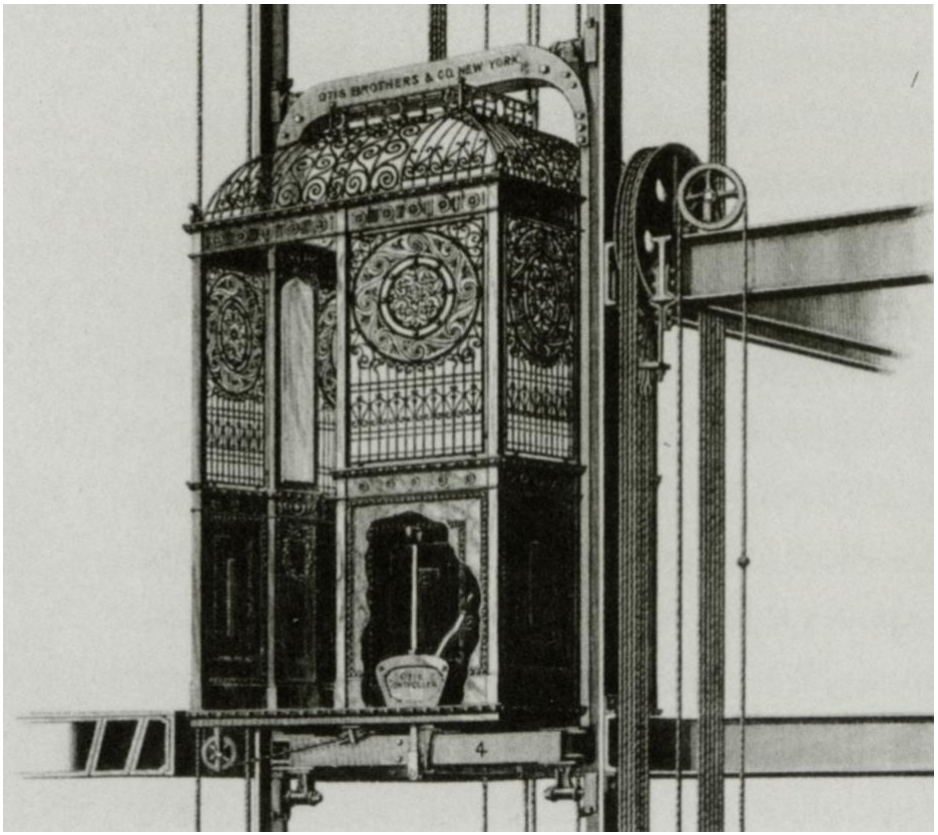
What Really Makes Science Grow

Are New Ideas,

Including False Ideas!

Vertical Transportation
In the Beginning

1854 Otis Mechanical Lift

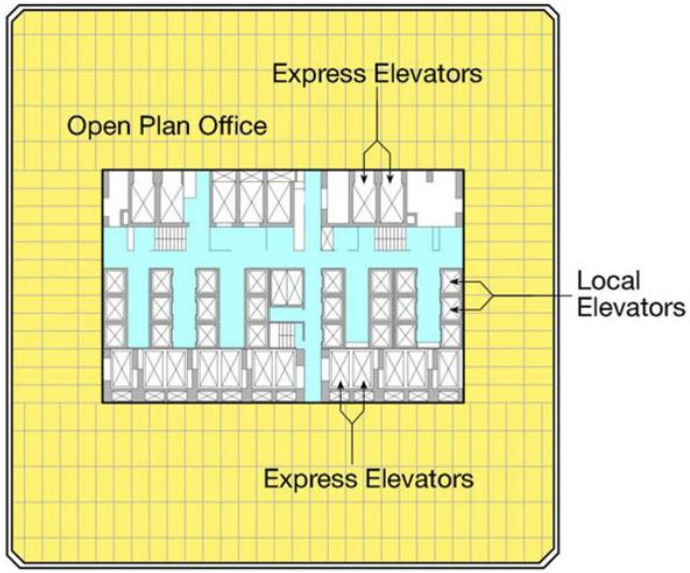


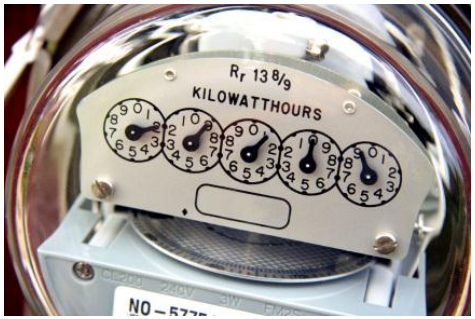
1900 Otis Brothers & Co elevator

The Challenge

Tall and super tall buildings struggle with :

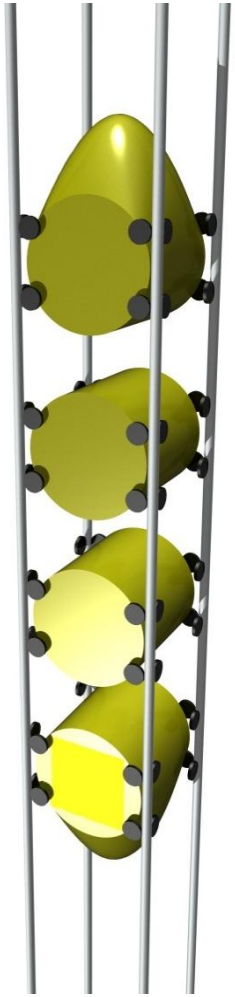
- Large number of elevators
- Large number of elevator shafts
- High electricity consumption
- Relatively slow elevator speeds
- Low floor area utilization ratios



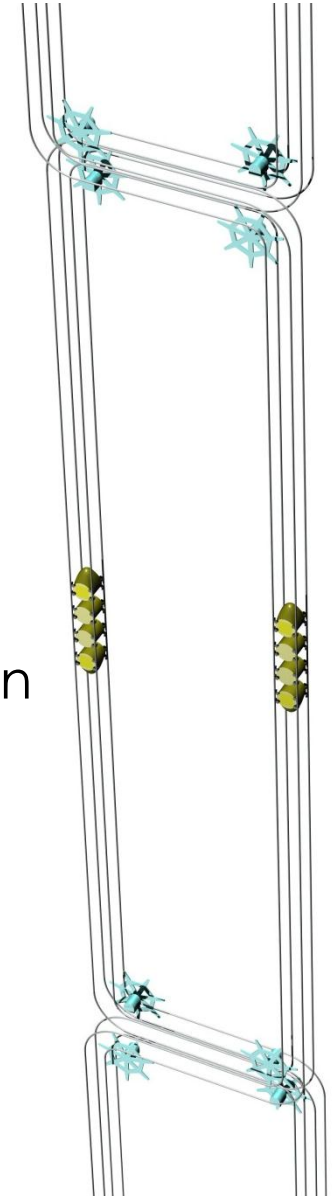


Which costs ¥ $ €

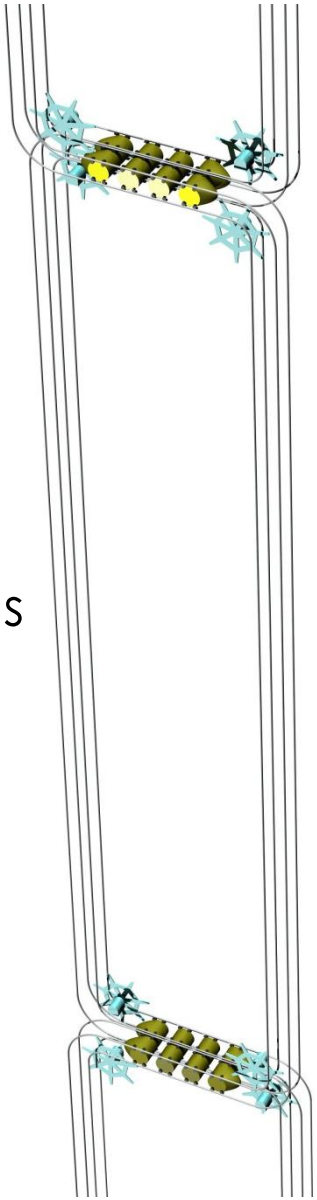
Articulated Funiculator Basic Concepts



One train is made of several train cars

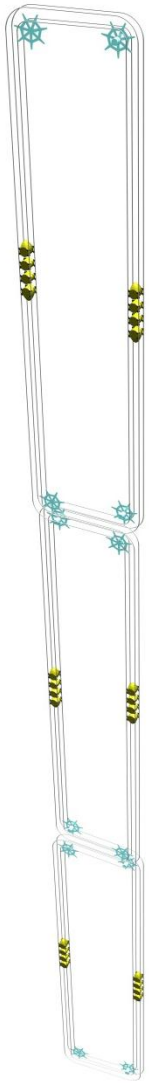


Trains in vertical legs

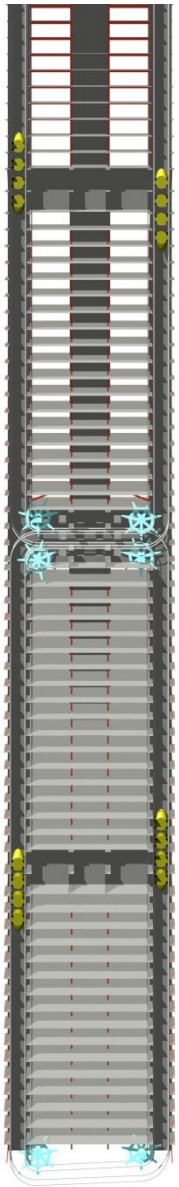


Trains parked at horizontal stations

Articulated Funiculator Basic Concepts

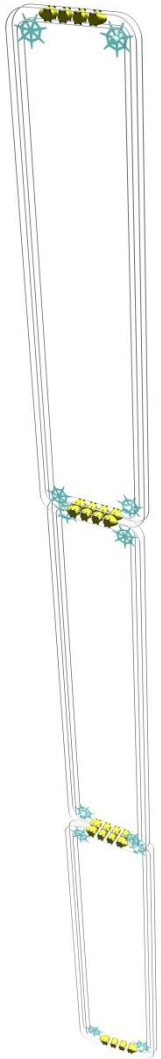


- A continuous, connected system of trains
- Moves people in masse
- Sustanable ”Sky Subway”

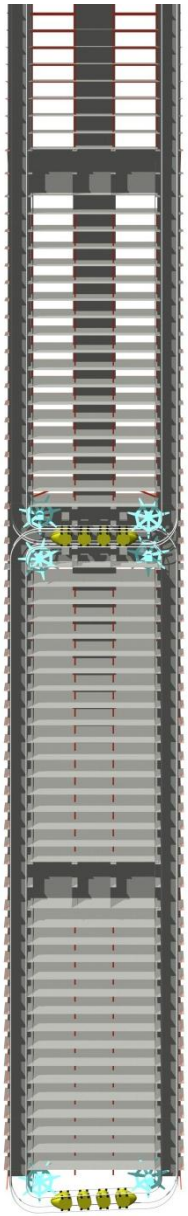


- Prototype building
- Trains in vertical legs

Articulated Funiculator Basic Concepts

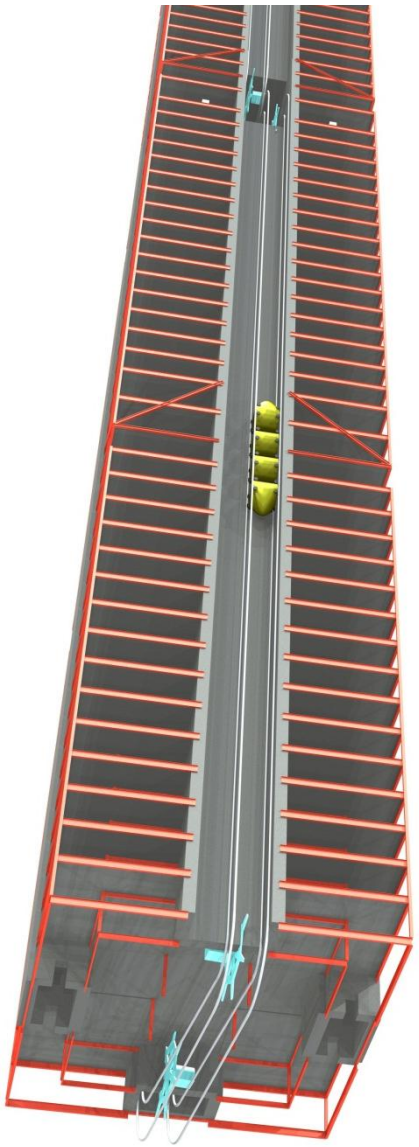


- Trains transition from horizontal alignments at the stations to vertical alignments between stations
- Passengers remain standing

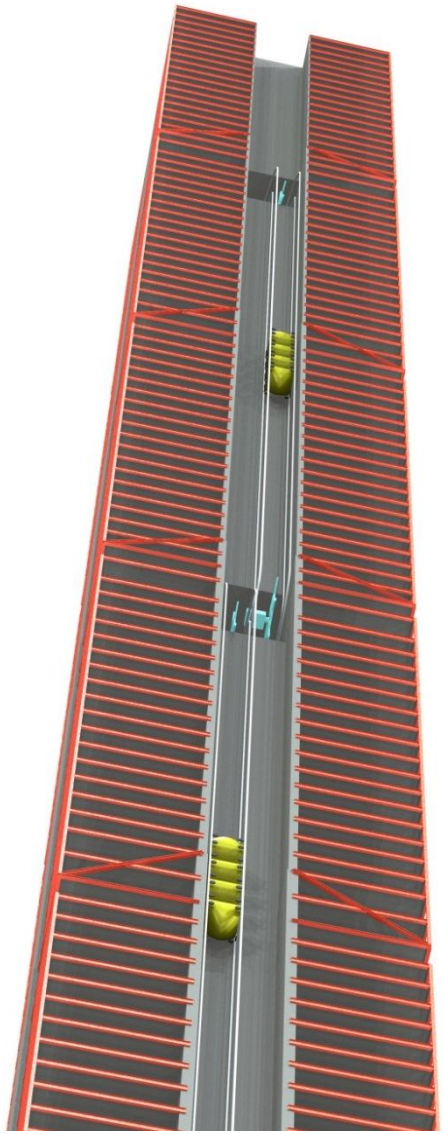


- Prototype building
- Trains parked at horizontal stations

Articulated Funiculator Basic Concepts

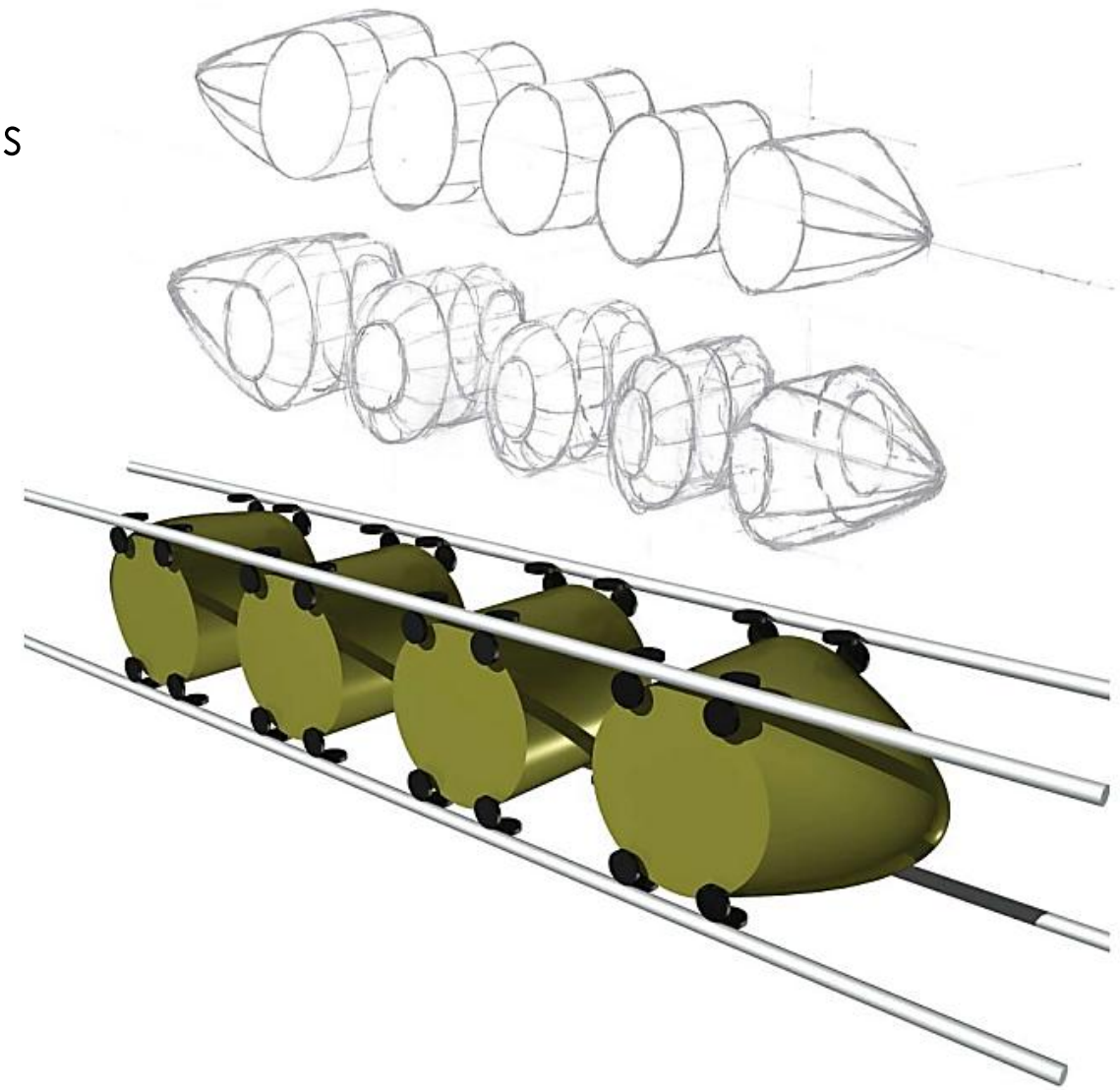


- Prototype Building
- Cut away
- Trains in vertical legs



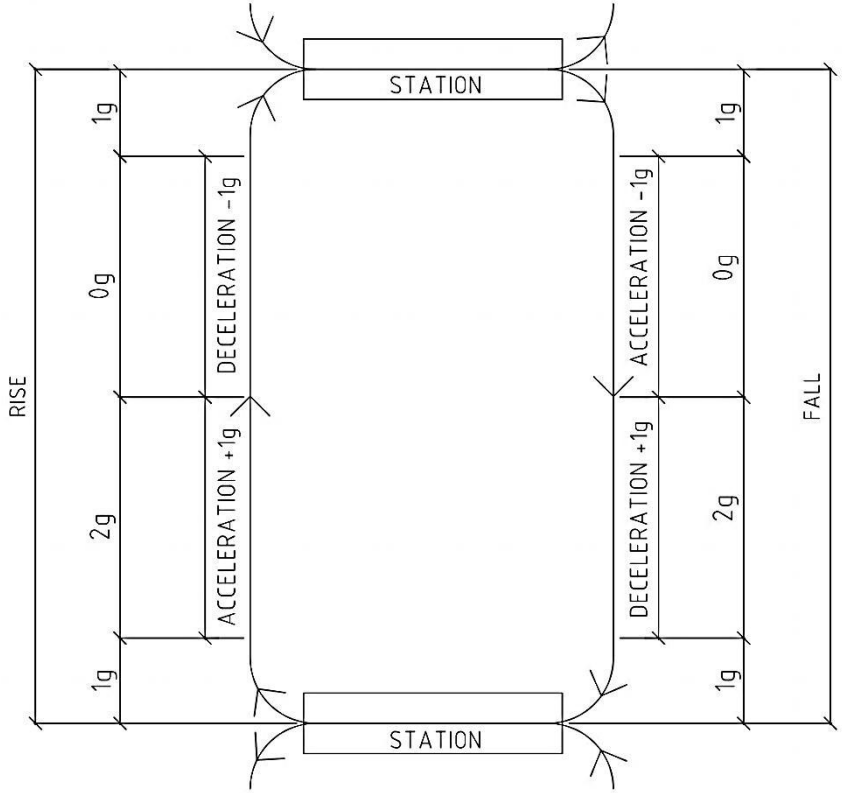
Train Development

- Articulated Funiculator is a series of trains
- One train is made of several train cars
- Passengers remain standing through vertical to horizontal alignment transitions



Acceleration and Velocity Strategies

- Ultra high speeds
- Short cycle times



Velocity Table

Rise/Fall (m)	Time (s)	Max Velocity (km/h)
200	9.03	159
225	9.58	169
250	10.10	178
275	10.59	187
300	11.06	195
350	11.95	211
400	12.77	225
450	13.55	239
500	14.28	252

Acceleration and Velocity Strategies

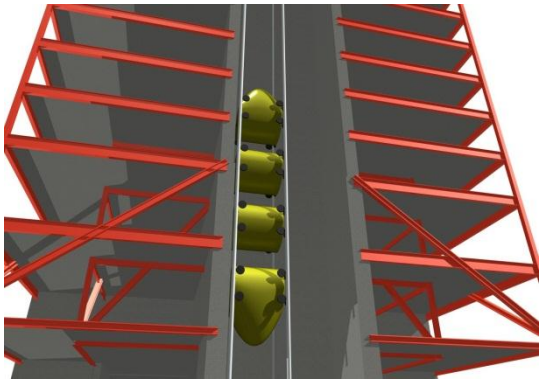
Ultra high speeds → Short cycle times

- Loading and un-loading 10-15 seconds
- Horizontal to vertical transitions (2) 10 seconds
- Rises and falls (200m – 500m) 9-14 seconds

Total cycles times between trains: 29-39 seconds

Cycle times can be reduced during off peak times

For example:
1000 m building
w/3 stations
time from bottom to top:
78 seconds!

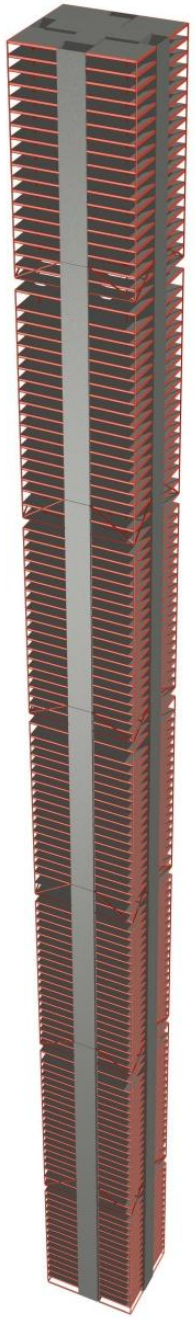


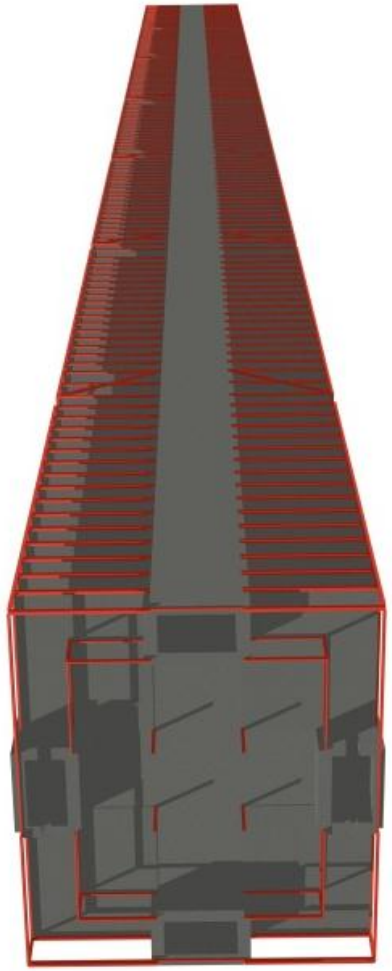
In the words of Nobel Laureate
Eugene O'Neill 1936:

Happiness Hates
The Timid,
So Does Science!

Tubed Mega Frame Prototype Building

- Height: 620m
- 40 m x 45 m plan
- 4 vertical tubed legs
- Slenderness ratios:
  - 1:15.5
  - 1:13.8





Tubed Mega Frame Prototype Building

- 4 cross-tube stations
- 4 intermediate cross-tubes
- High strength concrete
- Gravity loads transfered to vertical legs at stations and intermediate cross-tubes

- Increased building stance

- Very efficient super structure

Tubed Mega Frame Structural Performance

Vertical wall thicknesses:

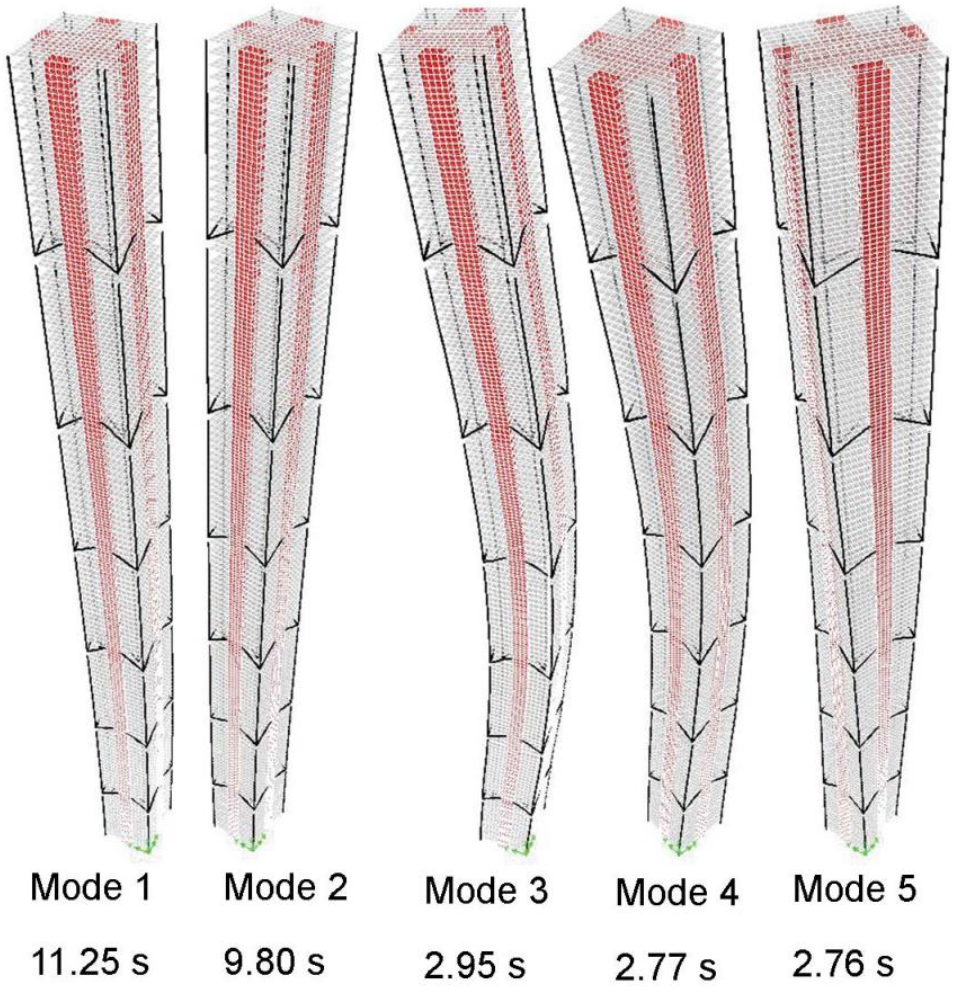
- 1.50 m at base
- 0.30 m at top

83 mph (37.1 m/s) wind:

- Strength
- C60 – C70 concrete expected

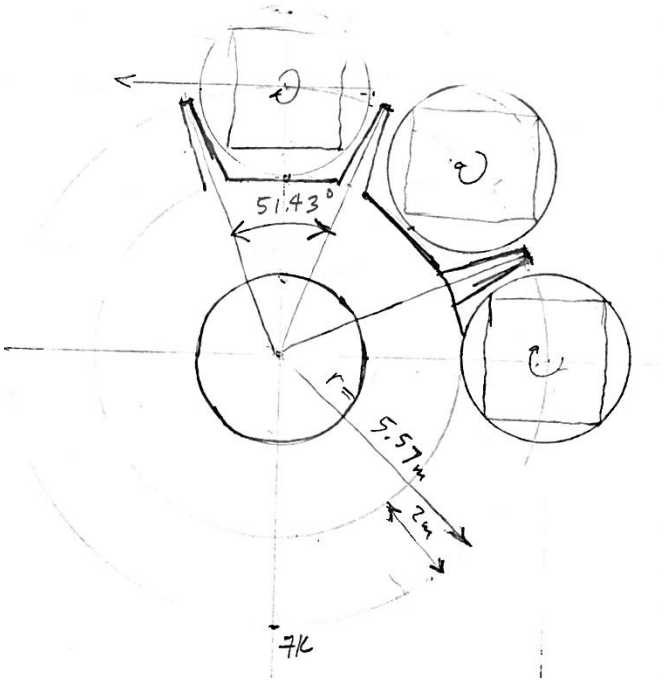
77.5 mph (34.6 m/s) wind:

- Deflections
- H/400 drift, 40 m direction
- H/580 drift, 45 m direction

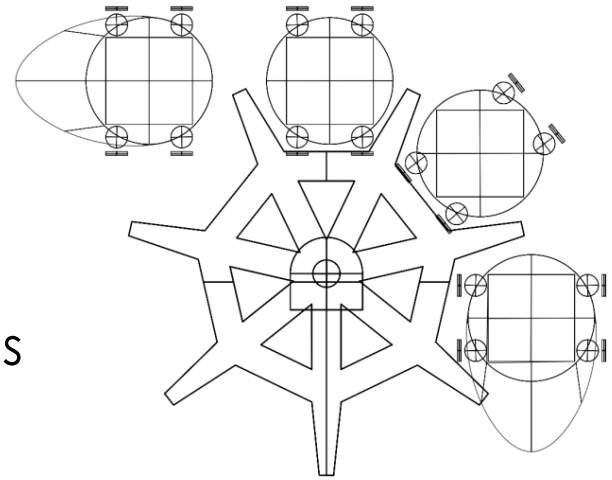


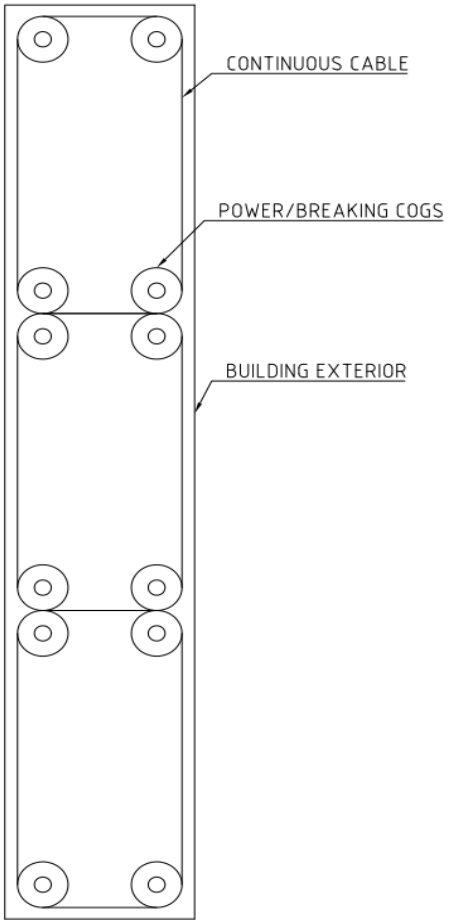
Power/Braking System

- Dynamic braking
- Energy storage and re-use
- Energy to brake the system = energy to power the system
- Sustainable



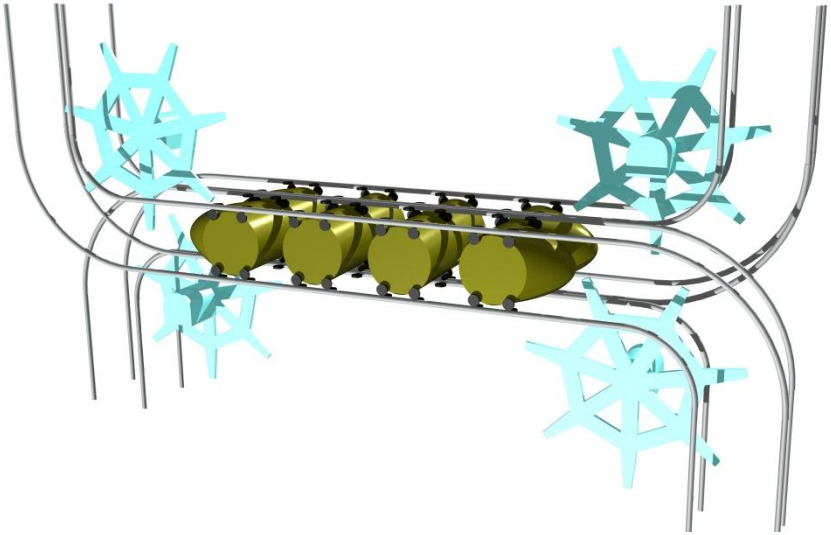
Power/Braking cogs



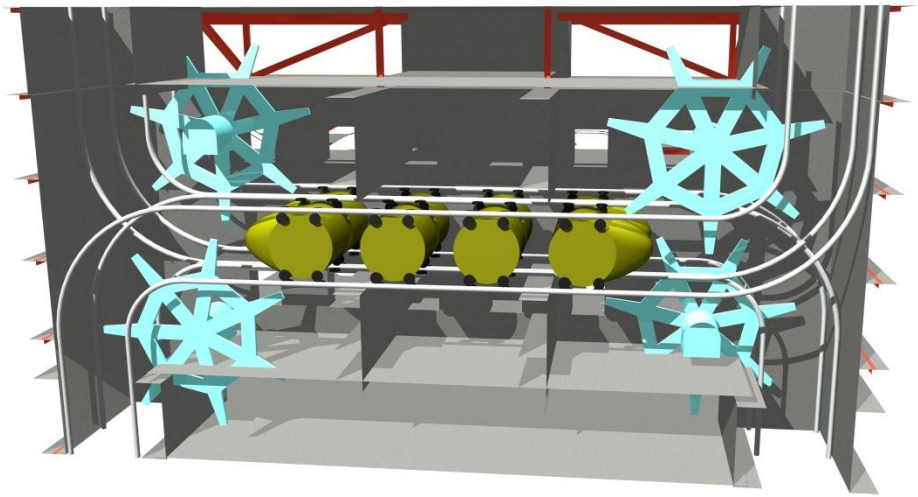


Power/Braking System

- When downbound payloads are heavier than the upbound
- The Articulated Funiculator captures energy from braking the trains and stores it
- The stored energy is used to accelerate the Articulated Funiculator when the upbound payloads are heavier than the downbound
- Capture are re-use of energy is sustainable

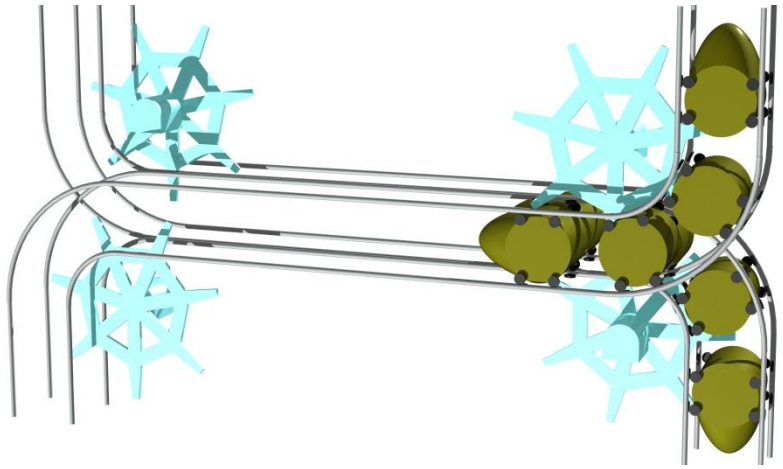


Trains parked at horizontal stations



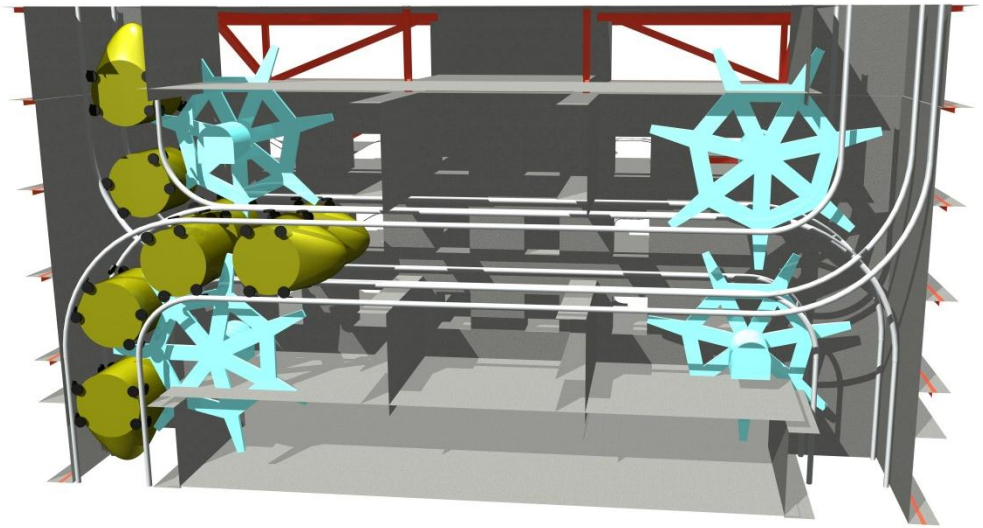
Power/Braking System

- For example;
- Before lunch most passengers will travel down
- The energy needed to brake the system will be stored
- The stored energy will power passenger up after lunch



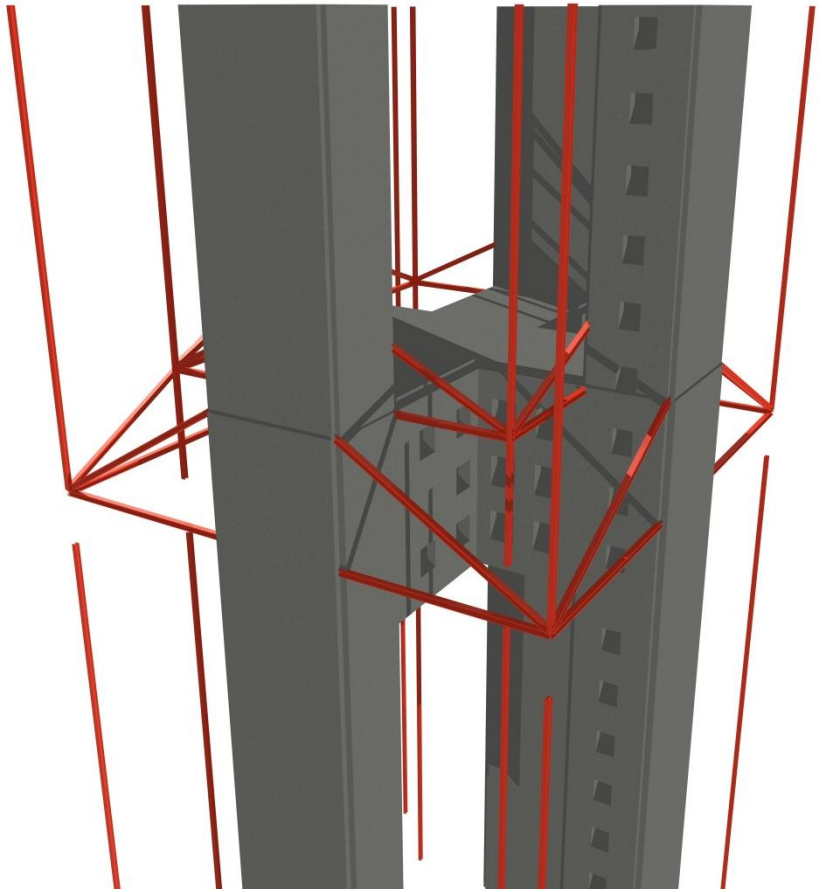
Trains in transition from horizontal to vertical alignments

Passengers remain standing



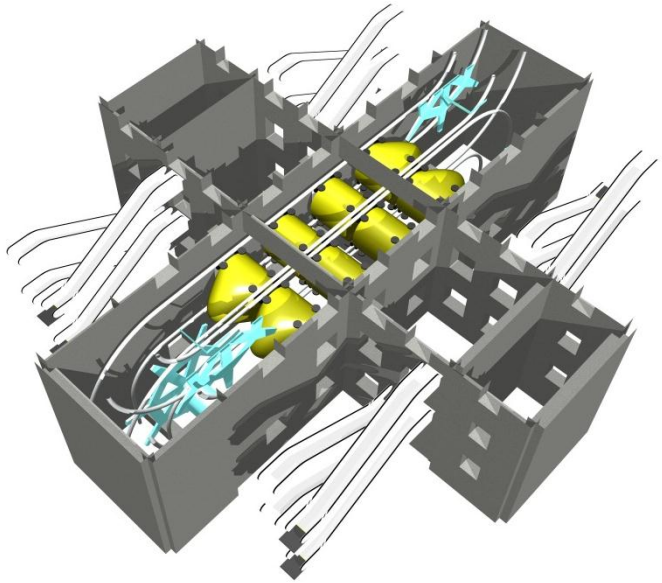
Train Station Concepts

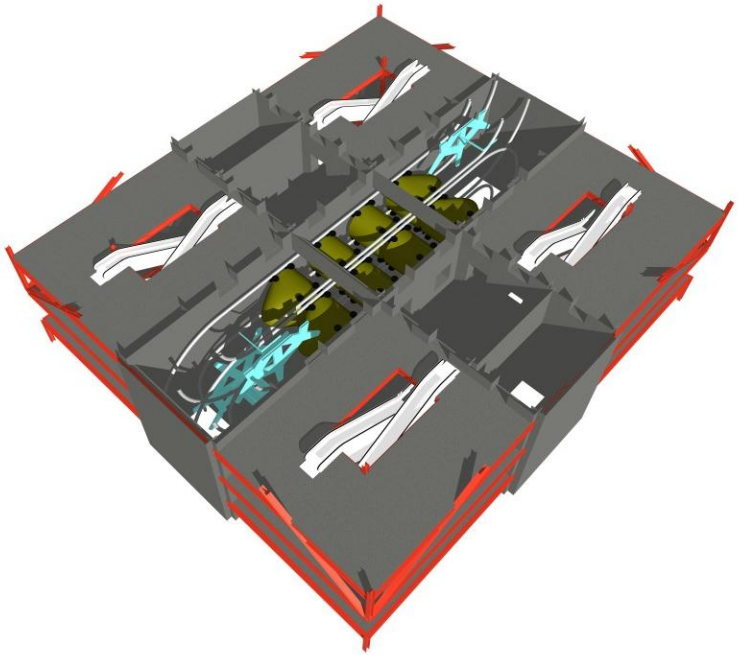
- 3-story cross tubes
- Load and unload from center story
- Transfers to the opposite sides of the building
- Transfers to conventional elevators



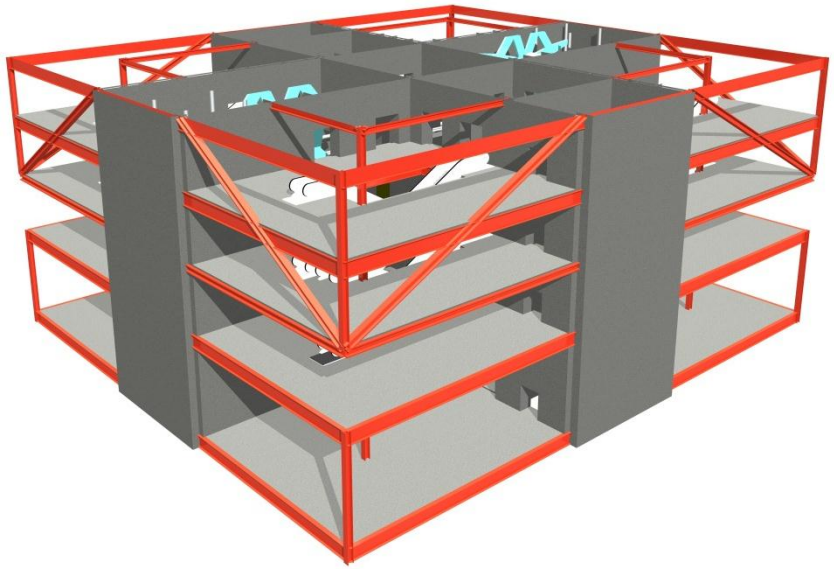
Train Station Concepts

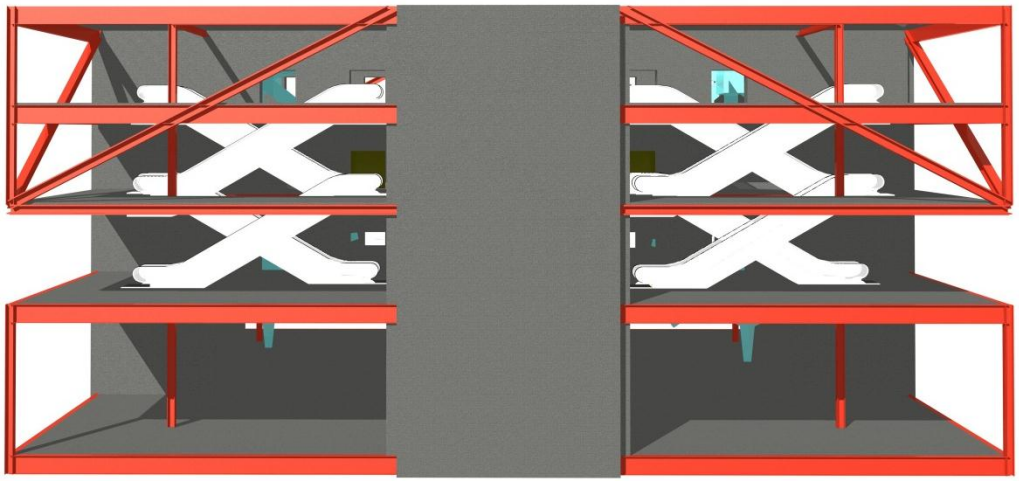
- Power/Braking systems housed inside the stations
- Passengers transition up to take conventional elevators up
- Passengers transition down to take conventional elevators down





Train Station Concepts



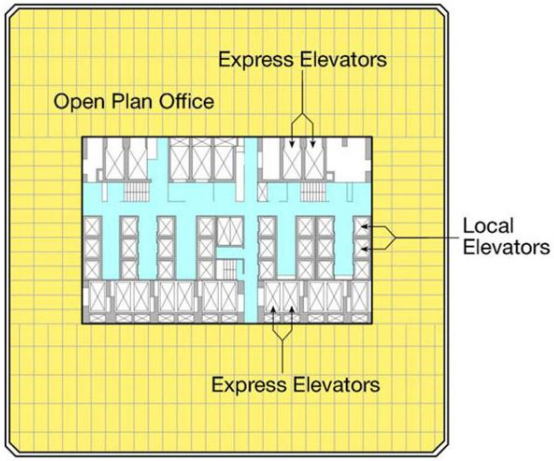


Floor Utilization Ratios

The central core in tall buildings consumes floor space → low floor space utilization ratios

Floor utilization ratios for building with a central core:

0.596 – 0.745 (0,6705 average)

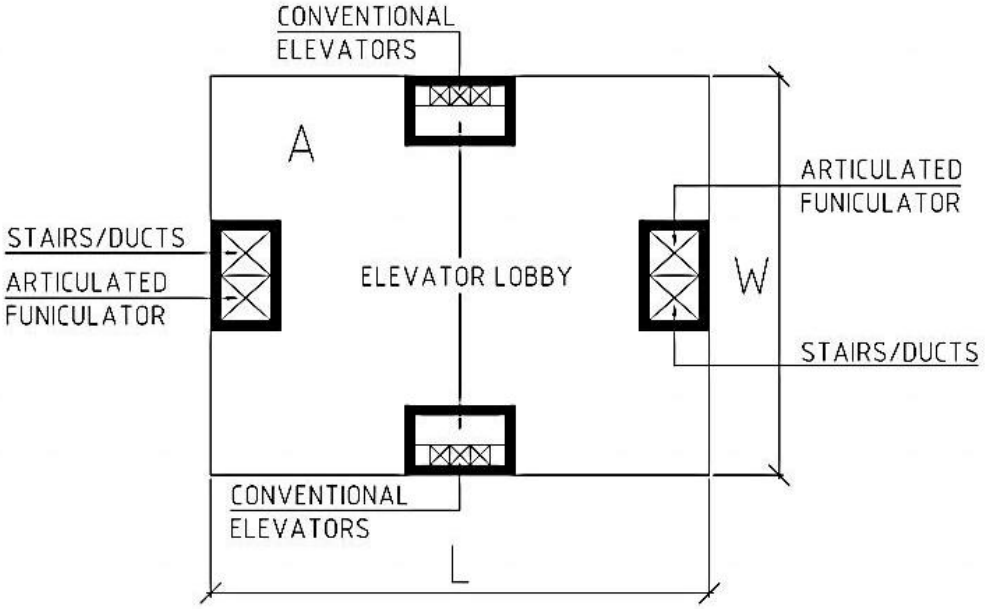


Floor Utilization Ratios

Floor utilization ratios for building with the Articulated Funiculator and the Tubed Mega Frame: 0.808 – 0.914

Approximate percentage increase in floor utilization:

0,861/0,6705 = 1,28 → 28% increase in rentable / sellable floor space

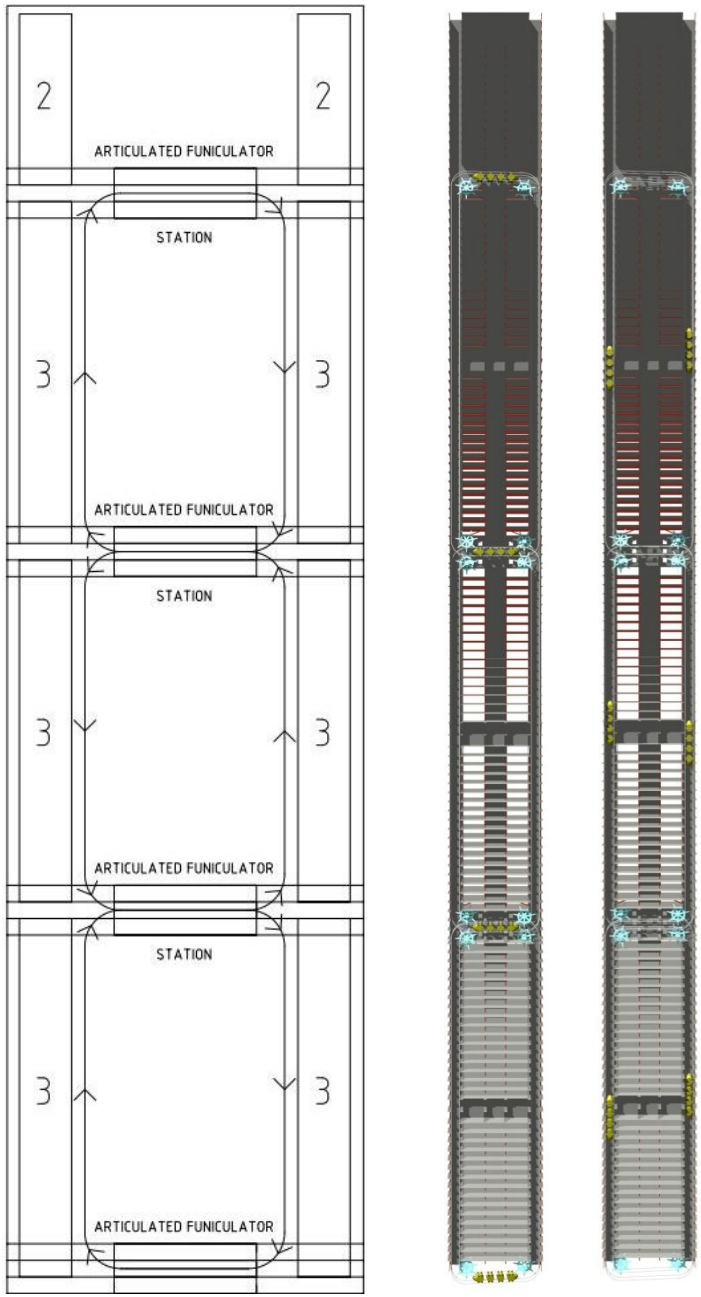


Floor plate	Lenght (m)	Width (m)	Floor plate (m^2)	Core area (m^2)	Ratio
A	40	40	1600	308	0,808
A	45	40	1800	308	0,829
A	45	45	2025	308	0,848
A	40	50	2000	308	0,846
A	45	50	2250	308	0,863
A	50	50	2500	308	0,877
A	55	55	3025	308	0,898
A	60	60	3600	309	0,914

Vertical Transportation Plan

- 4 articulated funiculator train stations
- 6 articulated funiculator trains
- Conventional elevators between train stations
- 22 conventional elevators
- Movement options:
  - Funiculator up then elevators up
  - Funiculator up then elevators down
  - Elevators all the way up

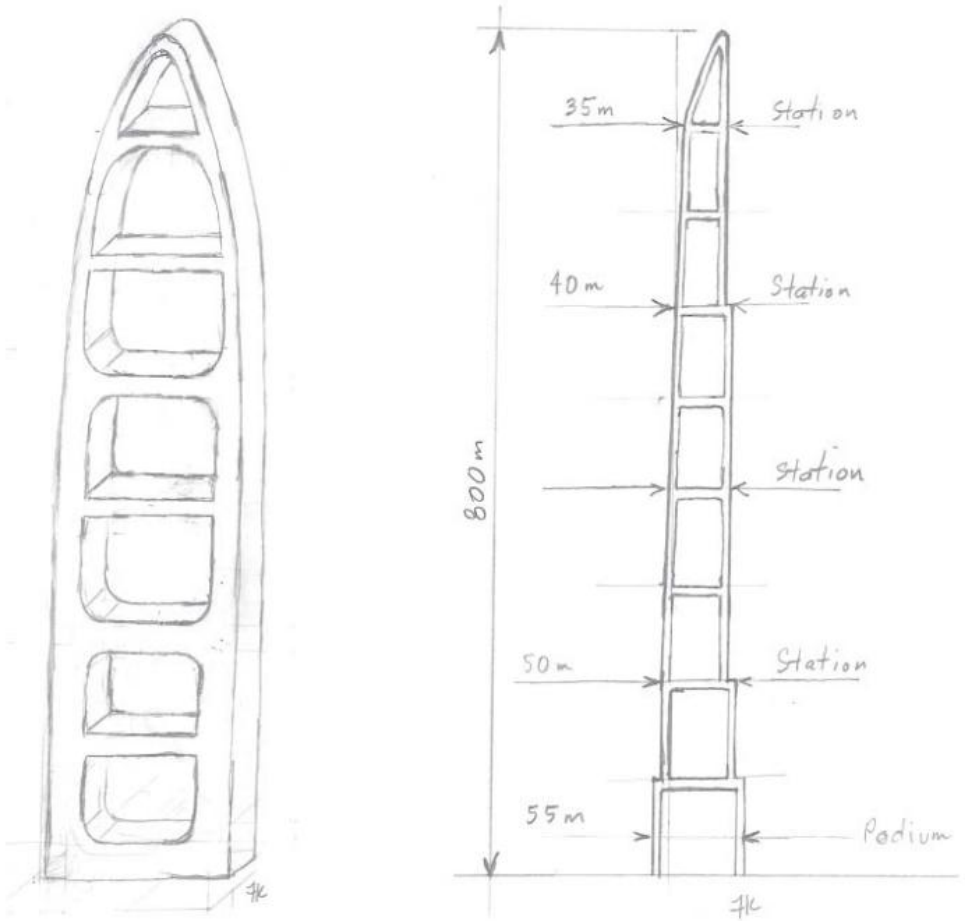
High passenger flow and reduced congestion



Architectural Programs

Articulated Funiculator and the Tubed Mega Frame

- Can support many architectural forms and shapes
- Slants, curves and stepbacks are supported



Architectural Programs
Articulated Funiculator and the Tubed Mega Frame

No central core → open floor plates and allows:

- Concert halls
- Large conference rooms
- Theaters
- Swimming pools
- Hospitals
- Schools

To be incorporated into tall thin skyscrapers




Comparison with Ten High-Rise Buildings

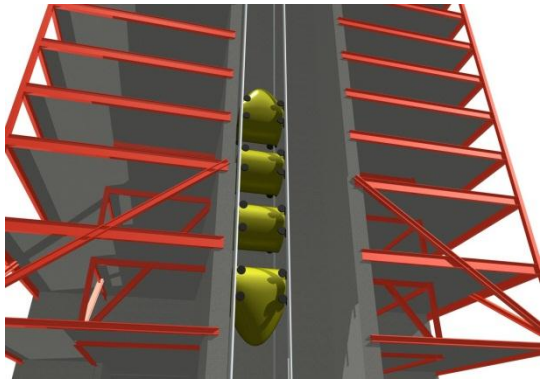
Name	City	Height (meter)	floors	compleated	Total number of elevators	Top Elevator Speed (m/s)	Building width (m)	Core width (m)	Floor plate (m^2)	Core Area (m^2)	Useble Floor Area Ratio	Building Slenderness factor
Ping An IFC	Shenzhen	660	115	2015	76	10	56	30	2925	964	0,670	1/12
Shanghai Tower	Shanghai (CN)	632	121	2014	106	18	65	30	2463	996	0,596	1/10
Chicago Spire	Chicago	610	150			-	60	28	2400	975	0,594	1/10
Taipei 101	Taipei	508	101	2004	61	16,8	56	30	3190	1084	0,660	1/9
Shanghai World Financial Center	Shanghai (CN)	492	101	2008	91	10	58	30	3334	882	0,735	1/9
International Commerce Centre	Hong Kong	484	108	2010	83	9	52	28	2555	792	0,690	1/10
Petronas Towers	Kuala Lumpur	452	88	1998	39	7	56	23	2356	600	0,745	1/8
Jin Mao Tower	Shanghai (CN)	421	88	1999	61	9	54	27	2356	602	0,744	1/8
Two International Finance Centre	Hong Kong	412	88	2003	62	10,6	55	26	2196	675	0,693	1/8
CITIC Plaza	Gunagnzhou	390	80	1996	36	-	47	24	2190	598	0,727	1/8
Prototype Building		620	120		22	44	40x45		1800	308	0,829	1/15,5

Conclusion
Articulated Funiculator

- Reduced number of conventional elevators
- Reduced number of elevator shafts
- Increased rentable / sellable floor area ratios
- Dynamic braking → Energy storage and re-use

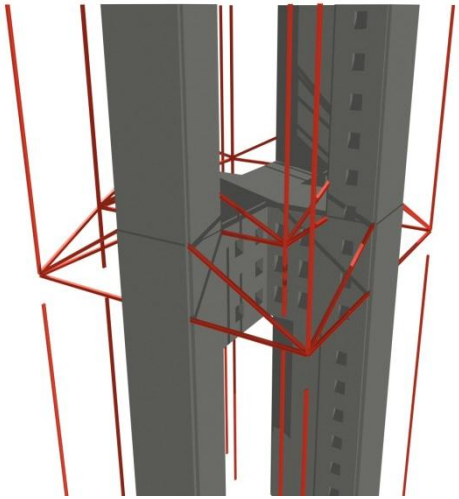
→ Sustainable system

- Ultra fast speeds
- Short cycle times



Conclusion
Tubed Mega Frame

- Only 4 vertical tubed mega columns
- No outriggers or outrigger connections
- No belt trusses
- No central core
- Smaller floor plates
- All loads at building perimeter
  - Sleek, very efficient super structure



In the words of Nobel Laureate

Albert Einstein:

We cannot solve our problems with the same thinking we used when we created them!


The sky´s the limit!

TYRÉNS

Tyréns presented
The Articulated funiculator and the Tubed Mega Frame
at the council on Tall Buildings and Urban Habitat
9th World Congress September 19-21, 2012 Shanghai

Fritz King (Tyréns) presenting

Fritz King (Tyréns) and Dag Wingstrand (Tyréns) at speaker´s table


Fritz King (Tyréns) and Samuel Salavaara (Tyréns) with Iris Y. Gan (Adrian Smith + Gordon Gill Architecture)

"Why haven´t we seen this before?!"

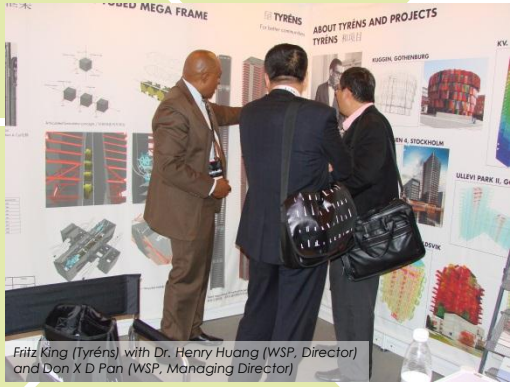
"Outstanding!"

"Blown away!"

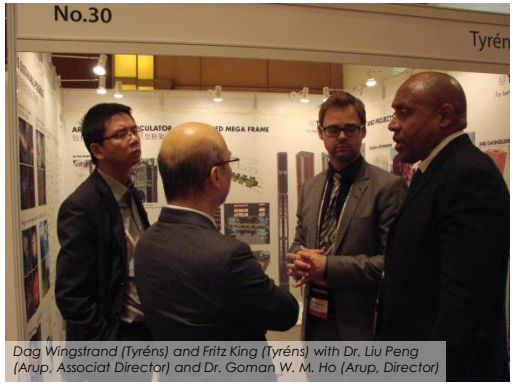
"Brilliant!"

"Excellent!"

"Visionary!"



Fritz King (Tyréns) with Dr. Henry Huang (WSP, Director) and Don X D Pan (WSP, Managing Director)



Dag Wingstrand (Tyréns) and Fritz King (Tyréns) with Dr. Liu Peng (Arup, Associat Director) and Dr. Goman W. M. Ho (Arup, Director)

As hailed by international high-rise experts:

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